Let $\underline{F}(x, y, z) = (x + y)\underline{i} + (y^2 + z)\underline{j} + xz\underline{k}$ for each $(x, y, z) \in \mathbb{R}^3$.

a) Find $\int_C \underline{F} \cdot d\,\underline{r}$ where the path of integration C specified by $z = 1 + x^2 + y^2$ and $x = 2y$ from $(0, 0, 1)$ to $(-2, -1, 6)$.

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a) The position $S(t)$ of a particle moving in an accelerator at time t is given by,

$$S(t) = \sin t\,\underline{i} + t\cos t\,\underline{j} + (t^2 + e^t)\underline{k}.$$

Find the velocity and acceleration of the particle at $t = \frac{\pi}{2}$.

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a) Evaluate $\int_1^2 \underline{F}(t)dt$ where $\underline{F}(t) = (t^4 + t + 2)\underline{i} + (e^t + \sin \pi t + t)\underline{j} + te^{t^2}\underline{k}$.

b) Let $\underline{F}(x, y, z) = (xy + 2)\underline{i} + (x^3 z - yz^2)\underline{j} + (x + y + 3z)\underline{k}$ and C be the path from P to S, defined by straight lines PQ, QR, RS where $P \equiv (2,0,0), Q \equiv (2,1,1), R \equiv (1,1,1), S \equiv (2,2,2)$. Evaluate $\int_C \underline{F}(x, y, z) \cdot d\underline{r}$ where $d\underline{r} = dx\underline{i} + dy\underline{j} + dz\underline{k}$.

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a) A particle moves along a curve $x = 5t + 1$, $y = 5t^3 + t - 1$, $z = 4t$ where t is the time. Find the components of velocity and acceleration at time $t = 1$ in the direction $\underline{i} + 2\underline{j} + 2\underline{k}$

b) Find the equation for the tangent plane to the surface $2xy - z^3 + 4x = \overset{-2}{\cancel{10}}$ at the point $(1, 1, 2)$.

c) Determine the directional derivative of $\phi = xyz^3 + x^3 y + z$ at the point $(1, 2, 1)$ in the direction of the vector $\underline{i} + 2\underline{j}$.